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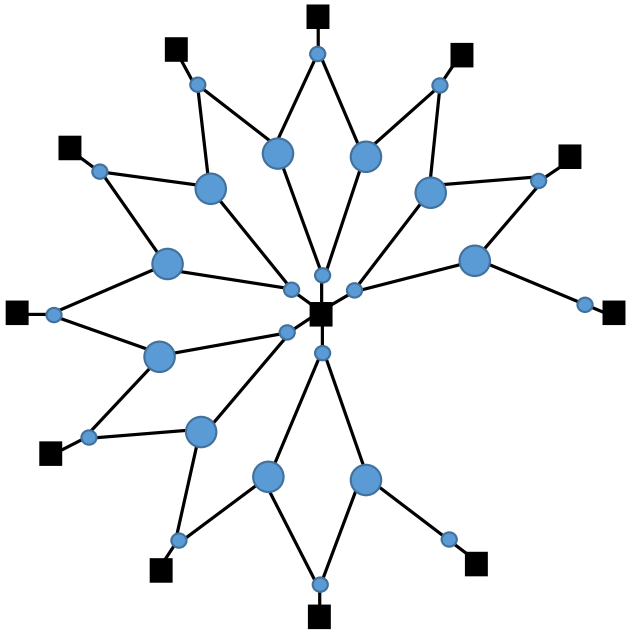

Design of mooring system for point absorbing wave energy devices in an array system

Master's thesis in the international master's programme Naval Architecture and Ocean Engineering

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Cover:
Example of an array configuration among the developed concepts.

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Abstract

The future energy production must be renewable to reduce the carbon emissions and ocean energy technologies provide solutions. Ocean waves have great potential, 0.1% of the energy in ocean waves could to cover the global energy demand five times over. Most of the ocean energy technologies are considered to be in a precommercial phase and need technical development. In 2016 a Swedish company, Waves4Power installed WaveEL, a full-scale prototype of one floating point absorbing WEC (wave energy converter). The next step towards full commercialization is to increase the capacity by designing array systems of several WECs.

The main objective of this thesis is to study array systems of floating point absorbing WECs focusing on design solutions of the mooring system. This is an important step towards fully commercial energy production using floating WECs. A literature study and interviews are used to create a basis for the design process that uses WaveEL as a reference. The installed WaveEL is used as a reference in the study and it is moored with three polyester mooring lines, each having one floater and one gravity anchor. By developing a number of conceptual mooring systems for different array configurations, solutions for different environmental conditions are obtained. The top concepts are evaluated towards the reference regarding cost, environmental impact and risk by using the tools LCOE (Levelized cost of energy), LCA (life cycle analysis) and risk assessment. The fatigue life and energy absorption from the waves are calculated from force responses in the mooring lines and heave motions of the WECs obtained from coupled hydrodynamic and structure response analyses in the DeepC software.

22 concepts were generated and by using systematic elimination matrices, Pugh and Kesselring, 4 top concepts were chosen. The top 4 concepts were further investigated in the LCOE, LCA, risk assessment and evaluated regarding fatigue life and energy absorption. The concepts are designed for the same geographical conditions as the reference, hence the water depth is limited to a range of 75-200m. In two of these concepts, LessIsMoor and MoorToIt, the WECs are moored with two mooring lines each and are designed for a water depth of 200m. In the other two concepts, MoorPower and StarBuoy, the WECs are moored with three mooring lines each and are designed for a water depth of 75m. It was seen that the top four concepts have lower LCOE and lower LCA than the reference. In the risk assessment it was found that LessIsMoor has risks that need to be reduced due to the high loads in the mooring lines. The fatigue analyses are based on the most common sea state at the operating location. In comparison with the reference, the results implied a longer fatigue life of MoorToIt and shorter fatigue lives for the other three concepts. LessIsMoor, MoorToIt and StarBuoy obtained higher power captures than the reference.

Based on the results and findings in this study, LessIsMoor was concluded as the concept showing the greatest potential considering LCOE, LCA and power capture. However, it was also the concept with the highest risks and other materials must be investigated before this concept is ready for the commercial market. Because of this, an alternative concept was recommended. Among the concepts using floaters, StarBuoy had the lowest LCOE and lowest LCA. StarBuoy also had the second highest energy absorption and was considered technically ready for commercialization.

Keywords: Array systems, coupled analysis, mooring system, systems engineering, wave energy